The Ecology and Acoustic Behavior of Minke Whales in the Hawaiian and Pacific Islands

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LONG-TERM GOALS

The long-term goals of this research project are to improve our understanding of the acoustic ecology and behavior of minke whales in the Hawaiian and Pacific Islands. Our specific goals are to develop and use passive acoustic methods that will allow us to survey, track movements, and monitor acoustic (and eventually non-acoustic behaviors) of minke whales. This will provide important information about the behavioral activities of minke whales at winter areas where they congregate in their breeding season. An additional goal is the assessment of localization accuracy for animals located from seafloor hydrophone arrays. This information is needed to estimate densities of calling animals from fixed hydrophones (e.g. the related DECAF research project).   Ultimately, the information and methods resulting from this project will allow for more effective conservation and management of this and other species that are vocally active but visually elusive.

OBJECTIVES

Our objectives are to use passive acoustic methods to detect and locate minke whales in the Hawaiian Islands area from a unique sound they produce called the 'boing'. Once animals are located, we collect detailed information on their acoustic and (when visible) non-acoustic behaviors. We will also

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14. ABSTRACT

The long-term goals of this research project are to improve our understanding of the acoustic ecology and behavior of minke whales in the Hawaiian and Pacific Islands. Our specific goals are to develop and use passive acoustic methods that will allow us to survey, track movements, and monitor acoustic (and eventually non-acoustic behaviors) of minke whales. This will provide important information about the behavioral activities of minke whales at winter areas where they congregate in their breeding season. An additional goal is the assessment of localization accuracy for animals located from seafloor hydrophone arrays. This information is needed to estimate densities of calling animals from fixed hydrophones (e.g. the related DECAF research project). Ultimately, the information and methods resulting from this project will allow for more effective conservation and management of this and other species that are vocally active but visually elusive.

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conduct acoustic line-transect surveys to estimate the abundance of calling animals in the study area. Animals will be located using passive acoustic methods from a quiet research vessel. These data will be used to validate and assess the localization accuracy of fixed seafloor hydrophone arrays located within the same study area. Acoustic data from the these seafloor hydrophone arrays are being collected concurrently with our vessel-based surveys and will be used in a related effort to estimate densities of calling animals from fixed hydrophones.

APPROACH

The study site is a large (> 2000 km^2) area of deep ocean waters located to west and northwest of the island of Kauai (Figure 1). This area is outfitted with several widespread sea-floor hydrophone arrays that are part of the Pacific Missile Range Facility (PMRF). Approximately 17 hydrophones from these arrays were used to collect acoustic data from calling minke whales by one of our collaborators, (Stephen Martin, SPAWAR). These data were processed in near real-time to localize calls of minke whales. Coincident with this effort, we deployed and monitored a towed hydrophone array system from an acoustically quiet motor-sailing research vessel (R/V Dariabar). Locations of calling animals based on 'boings' localized on the PMRF array were relayed by satellite phone and VHF radio to the R/V Dariabar so that the same animal could be located by our team. Marine mammal observers maintained watches when conditions were suitable and towed hydrophone arrays were used to obtain real-time localizations of calling animals using target-motion analysis. These data were used to independently validate locations of calling animals. Data from both the seafloor hydrophone array and the towed hydrophone array were post-processed to obtain better location estimates and assess sources of uncertainty in the detection and localization processing systems.

WORK COMPLETED

The field season began on 15 March and ended 28 April 2009. The first week of the field effort (leg I) occurred during moderately poor sea conditions (Beaufort 3-4, 2-3m swell) that eventually deteriorated to unworkable conditions (Beaufort 4-7, 3-5m swell) by the end of the second week. A decision was made to halt the field effort until conditions improved. Although acoustic and visual data were collected during this period, visual monitoring was greatly compromised. The second half of the field effort commenced on 19April when weather and sea conditions had greatly improved (Beaufort 1-3, swell < 2m) providing a much better opportunity to collect data.

A total of 21 days consisting of approximately 200 hours was spent at sea (including overnight voyages) for the entire field season (Figure 1). Eleven days of effort of effort were completed for leg I, and 10 days of effort for Leg II Effort was primarily conducted during daylight hours and consisted of both visual and acoustic monitoring. In total, approximately ~ 850 km of survey effort was completed inside the study site. A total of 131.5 hours of multi-channel acoustic data from the towed hydrophone arrays was saved to hard drives.

RESULTS

This report forms a supplement to the main report on this project. Here we describe the activities of the St Andrews partners.

Relatively little effort was planned for Janik and Thomas during FY2009; the bulk of their work is due to begin in October 2009 (see Timeline and Milestones, p30 of project proposal). All partners

participated in project start-up meetings, and planning meetings held in the run up to and during the 2009 field season, all via tele-conference. As planned, project PI Norris and partner Martin attended the distance sampling workshop taught by Thomas in July 2009, and held detailed discussions of the 2009 season and plans for 2010.

Janik and Norris developed the behavioural sampling protocol for data collection at sea. We created a list of priorities to be prepared for different observation conditions. We prioritized location data that are crucial for the calibration of the acoustic localization method, followed by information on individual identity and finally behavioural context.

Janik is collaborating with Martin and Norris in obtaining localizations using data collated from the towed array during 2009. In a first step, Janik investigated possible modifications to the classical towed array design to improve localization accuracy. For this, Janik tested a variety of transducer configurations using the recently developed Matlab code HYPAS (Vallarta Hernandez 2009). The best configuration possible with our research vessel would consist of two towed lines that have two transducers each. The transducer pairs need to be placed at different distances from the ship on their respective lines to maximize accuracy in depth determination. In the coming year we will decide whether such a configuration is feasible when the vessel is under sail. While towing two lines is advantageous, it may turn out to limit vessel maneuverability too much to collect useful data. Janik is also developing ways to feed acoustic data into an automatic localization process using Pamguard. For this, he collaborates with Doug Gillespie to optimize routines in Pamguard for the purpose of our project.

Localization data from the first year will form the basis for updating calculations of required effort for the passive acoustic line transect survey planned for 2010. The survey is designed to produce an estimate of vocalizing minke whale density, as well as density of vocalizations and vocalization rate. Density of vocalizations will be compared with one derived independently from the bottom-mounted hydrophones at the PMRF range, made as part of the synergistic DECAF project.

One aspect of the 2010 towed acoustic survey that is unconventional is that the survey tracklines cannot be planned far in advance, because the vessel will operate as much as possible under sail alone (to avoid disturbance of the animals) and hence feasible transect lines will depend upon prevailing weather conditions. Even coverage of the survey area within a survey period (1-2 days) may not be possible, and coverage will almost certainly vary between survey periods as wind directions change. Thomas is developing design tools within the industry-standard software Distance (Thomas *et al.* 2009) to allow generation of random survey tracks within these constraints, and tools to allow analysis of data from surveys with variable coverage. This work was begun in FY2009, and will be completed in parallel with the effort calculations mentioned above.

The visual observation of a minke whale made on 27 April confirmed that localization accuracy from the bottom-mounted hydrophones is good, an important consideration in estimating density using this hardware. Further dual visual-acoustic detections made in 2010 will further refine our knowledge about localization accuracy. As part of the DECAF project, Thomas and others are developing methods for estimating density that allow known measurement error to be factored in to the estimation procedure.

IMPACT / APPLCIATIONS

The towed arrays localizations and visual sighting from the R/V Dariabar were significant because they preliminarily confirmed that the accuracy of the seafloor array localization techniques is relatively good. Assessment of localization accuracy is important for validating the assumptions of methods being used in the related DECAF effort to estimate densities of calling animals from fixed hydrophones (Thomas et al. 2008). We will continue to collect data on this aspect of the project as well as work on improving the accuracy and efficiency of localization techniques. This should result in improvements of passive acoustic methods from both fixed and towed hydrophones for estimating animal density and abundance.

New and important information about the acoustic and non-acoustic behaviors of minke whales in their winter/spring (presumably breeding) areas was collected from our first field season. The 2009 season resulted in one of only three documented sightings of minke whales near the main Hawaiian Islands made by a research team in (the second was also by our research team 2006), and the only observations of a minke whales feeding in Hawaiian waters. Feeding behavior for minke whales has never been observed in the Hawaiian Islands, and only very infrequently observed for other commonly seen baleen species such as humpback whales. Acoustic behaviors of minke whales are poorly understood, especially for populations in the North Pacific. We have already determined that there are certain characteristics of the boings that are significantly different for animals from western and central (i.e. Hawaiian) North Pacific, an indication that several populations exist. We will continue to examine the acoustic characteristics of boings for additional insights.

RELATED PROJECTS

A related NOPP funded effort by Len Thomas and collaborators, Density Estimation for Cetaceans from passive Acoustic Fixed sensors (DECAF), is being conducted using some of the data collected from our effort and data from our collaborators. Our data will be used to assess and validate localization accuracy. Localization accuracy is important to assess for the assumptions and methods being developed for the DECAF effort.

Other related projects include efforts to record data from PMRF seafloor arrays to localize and track minke whales using boings. These two projects are being conducted by Stephen Martin (SPAWAR-San Diego, CA) and Eva Nosal (University of Hawaii-SOEST), respectively. Mr. Martin is collecting acoustic data from the PMRF hydrophone array concurrently with our field effort. These data were processed in near real-time and are being post-processed by Mr. Martin. Dr. Nosal post-processed the same data from the PMRF seafloor array to estimate localizations using a propagation model-based time-of-arrival (TOA) approach. Results from these efforts will be compared and validated with sighting data and towed array localizations collected from the R/V Dariabar using methods described in this report.

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